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Experimental techniques are presented which show that it is possible for preschool children to learn, in a relatively short time, what ordinarily are considered to be advanced skills. Preschool children of two-and three-years of age can learn to type on an electric typewriter, to print, to read, and to take dictation. The capacity to learn these skills at an early age is not unique to gifted children.

Some of the theoretical topics on which work is being done, especially those that pertain directly to the experimental techniques, include: Deontic logic, which is the formal analysis of normative relations; the logic of entailment, which is the formal analysis of strong implication and relevance; the formal analysis of interactional relations; the formal analysis of the structure of problems; and the formal analysis of the structure of environments.

The four stages which have been developed for permitting children to learn orthographic symbols are: the basic reading and writing stage which is comprised of learning steps in typing, printing, and reading; the dictation stage; the composition stage; and the dialogue stage. The teacher's role is to respond immediately to the child's responses. The time limit is one hour per session per day.

Children learn quickly within the context of a responsive environment. Some children are annoyed at having to stop at the time limit; others can learn for only 30 minutes of the session.

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ORTHOGRAPHIC SYMBOLS AND THE PRESCHOOL CHILD--A NEW APPROACH

Omar K. Moore
Sociology Department, Yale University

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ORTHOGRAPHIC SYMBOLS AND THE PRESCHOOL CHILD--A NEW APPROACH

Omar K. Moore
Sociology Department, Yale University

For a number of years my colleagues and I have been trying to understand what is sometimes called "human higher-order problem solving" and I have been especially interested in the relations between cognition and social interaction. Originally, I used school children and adults as subjects in experiments, and concentrated on the analysis of the "deductive" aspects of cognition. However, my research gradually came to include the study of "inductive" processes as well, so it was necessary to design experimental arrangements which would satisfy this interest. In 1958 I devised some techniques for studying the inductive processes of very young children.

This afternoon, I will discuss some of these experimental techniques and show that it is possible for preschool children to learn, in a relatively short time, what ordinarily are considered to be advanced skills. More specifically, even two- and three-year olds can learn to type on an electric typewriter (using correct fingering), to print, to read, and to take dictation. It is important to understand that the capacity to learn these skills at an early age is not unique to gifted children. In order to make my discussion seem less hypothetical, films will be shown of children, ages two through five, both normal and gifted, doing these things. From time to time I will interpolate some remarks about the theoretical background of these techniques and indicate the direction which my current research is taking.

Before turning to a discussion of the techniques, a few comments should be made about the interdisciplinary nature of this research. My project on the cognitive processes of young children is only one part of a more inclusive program of research; this larger program, of which I am the principal investigator, has as its primary objective the development of an experimentally grounded theory of human higher-order problem solving and social interaction. Its main sources of support are: The Group Psychology Branch of the Office of Naval Research, the Carnegie Corporation, the McGraw Foundation, the Thomas A. Edison Research Laboratory (West Orange, New Jersey), Hamden Hall (a private

country day school in Hamden, Connecticut) and Yale University. Funds from these organizations have made it possible to draw upon the research talents of specialists from a broad spectrum of disciplines: Edith Lisansky, clinical psychology; John A. Carpenter, experimental psychology; Rulon Wells, linguistics; Richard F. Curtis, sociology; Richard Kobler and Conrad Wogrin, engineering; Alan Ross Anderson, Nuel D. Belnap, Jr., and Frederic B. Fitch, mathematical logic. Each of these outstanding professionals has his own self-generated project, and each project is contributing to the over-all objective of the program. I wish there were time, today, to describe the various projects and to explain how they relate to the program. Instead, let me simply say that I think it is necessary to combine the efforts of specialists from many disciplines in order to solve challenging problems in any one of the bahavioral sciences; and with respect to the pressing need for a deeper understanding of theoretical problems in the bahavioral sciences, it is essential to take into account recent developments in mathematical logic.

As I remarked, it is not feasible today to discuss the many projects which make up the larger program. However, it may be helpful to at least enumerate some of the theoretical topics on which work is being done, especially those that pertain directly to the experimental techniques. Papers and monographs reporting some of the results of these investigations are now available.

(1) Deontic logic (the formal analysis of normative relations) and the logic of entailment (the formal analysis of "strong" implication and "relevance"). This research is being carried on primarily by Anderson and Belnap [1], [2], [3], [5]. It has a dual purpose with respect to its application here; (a) to create a new family of logics for analyzing the normative aspects of experiments, and (b) to provide criteria for evaluating the relevance, or irrelevance, of steps subjects take in attempting to solve problems.

(2) The formal analysis of interactional relations. Anderson and I have been collaborating on this topic for several years and we have developed a theoretical orientation which appears to be of value for the conceptualization of interactional patterns [4]. Our central

concepts are of a folk-model and of an autotelic activity. More will be said about the concept "autotelic activity" when we turn to the films.

(3) The formal analysis of the structure of problems. Most behavioral scientists would agree that an analysis, or even a description, of an experiment would be incomplete if so-called "task variables" were not conceptualized. The importance of such variables is undeniable. Unfortunately, the analysis of the structure of the task or problem facing a subject is still at a very primitive level. It occurred to Anderson and me that we might draw upon the resources of recursive function theory for help in this matter. We found that John Myhill [17], a mathematical logician, had come to much the same conclusion and so we adopted his terminology with slight modifications. From the standpoint of recursive function theory, any problem which human beings might face falls into one of the following three classes: effective, constructive, or prospective.[1] The criterion for distinguishing these three classes of problems is the solvability of an arbitrary member of the class through the use of an algorithm. We call a class of problems "effective" if there is an algorithm for solving an arbitrary problem in the class; or if the problem has no solution the algorithm will reveal this fact. A class of problems is called "constructive" if there is an algorithm for solving an arbitrary problem; but if a given problem has no solution, then the algorithm will not indicate that there is no solution. Finally, a class of problems is called "prospective" if there is no algorithm for finding a solution to an arbitrary member of the class or for discovering that there is no solution if there is none. Human beings frequently solve difficult problems which do not admit of algorithms (or if there are algorithms it is impractical to use them). How is this possible? By definition neither innate nor acquired algorithms are used. To me, this strongly suggests that human beings,

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[1]Sometimes it is convenient to have a single term for the non-effective classes of problems; we use the term "heuristic" to cover both the constructive and the prospective classes of problems.

very early in life,[2] somehow develop very powerful problem-solving schemata--schemata which are not algorithmic, yet do lead to solutions much more often than one would expect by chance alone.

For those of you who are interested in the formal analysis of the structure of problems, consult the bibliography in Myhill's paper, "Some philosophical implications of mathematical logic" [17].

(4) The formal analysis of the structure of environments. This topic is one which has been of special interest to me. Although it lies beyond the scope of the present discussion to explain my analysis of environments, I would like to call your attention to one class of environments which is important for investigations of cognitive processes. More particularly, I would like to introduce the notion of a responsive environment for children. I will say that an environment is "responsive" if it satisfies the following conditions: (a) it is attuned to children's exploratory activities, (b) it informs children immediately about the consequences of their own actions, (c) it permits children to make extensive use of their capacities for discovering relations, and (d) it is so arranged that children are likely to make a series of interconnected discoveries about some aspect of the physical, cultural, or social world. If you think about the concept of a responsive environment I believe that you will be led to the conclusion that such an environment would be conducive to the development of problem-solving abilities. In my research with children I have attempted to construct environments of this kind.

I hope that the preceeding account of some of the theoretical topics that are of interest to my colleagues and me will serve to introduce the experimental techniques, so let us now go to the techniques themselves.

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[2]One kind of evidence for the power of very young children's "computers" is the fact that they learn a natural language without the aid of a language. Most children master the ground rules of a complex natural language by the time they are three years old. This is a task of almost unbelievable complexity, yet we are surprised only by the children who fail to learn. This learning of a first language is a prospective problem for children.

Here is an outline of the four stages of the system which I developed for teaching children (or better, permitting them to learn) orthographic symbols.[3]

I. Stage I - Basic Reading and Writing

A. Steps--typing

1. C (child) explores typewriter (electric), T (teacher) responds by naming each character C makes. (T also gives phonetic value of some characters.)
2. C gives T's response to C's making of characters.
3. T exhibits characters on projector. C responds by striking appropriate key and T repeats C's verbal response. (By this time, correct fingering is achieved through T's use of off-on switch.)
4. T exhibits word list on projector, C responds by typing the characters in proper order. T then pronounces the word.
5. C makes T's response to words.
6. T exhibits sentences on projector, C types words (including punctuation) in proper order. T no longer responds except to help when C is confused.
7. C types autonomously. (A control is added to projector so that C can do this by himself.)

B. Steps--printing

1. T makes available blackboard and chalk to C at the beginning of typewriter training.
2. At some time C will begin to make letters, words and sentences on his own; T corrects mistakes after this process has begun.

C. Steps--reading

1. T presents word lists and stories (from C's previous typing) on projector. C reads, T corrects (having first given C an opportunity to work through the difficulty).
2. T provides books so that C may read autonomously.

II. Stage II - Dictation

A. T records C's verbal responses while C types, then C listens to himself.

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[3]To many linguists the expressions "written language" and "spoken language" are anathemas; from their standpoint, language means "spoken language"; systems of writing, including mathematics, are mere language auxiliaries. Since there does not seem to be a generally accepted term which covers what I want to talk about, I use the expression "orthographic symbols" to denote any form of writing which permits useful "translations" from written symbols to spoken ones, and from spoken symbols to written ones. I am not using the term "orthographic" in the narrow sense of "correct spelling."

B. C reads typed material while listening to himself.
C. T adds recording-reproducing unit with keyboard control to typewriter, as well as off-on switch for the projector. C explores these controls and T responds by naming them.
D. C reads (but does not type) prepared story on projector (reading punctuation as well), and then takes his own dictation on typewriter.
E. C takes dictation on typewriter from other recorded voices.

III. Stage III - Composition

A. C dictates his own stories, with T present, and then types them.
B. C dictates his own stories, with T absent, and then types them. T inspects and corrects C's work.
C. C dictates and types privately and is encouraged to start a diary. T does not intrude.

IV. Stage IV - Dialogue

A. T collects samples of C's verbal interaction with others. C's task is to type these recordings as a dialogue, assigning utterances to the proper persons.
B. T records interaction in contrived game situations of the kind devised by Moore (for one example see [11]).

As the outline indicates the child begins by exploring an electric typewriter. The teacher's role is to respond immediately to the child's responses. To give you some notion of how children actually behave in Stage I-A-1, let us watch a boy, two-years seven-months old, on the occasion of his first experience with an electric typewriter. This boy comes from a family whose class position is in the III to IV range (according to Hollingshead's index of social class position). His parents are warm, intelligent people with a permissive attitude toward him. In terms of a clinical evaluation, as well as my own observations, he is a happy, well-adjusted, normal child.

Film Excerpt 1

[from EARLY READING AND WRITING: PART 2 [14]--four minutes. Child freely explores electric typewriter; instructor pronounces the name of each character as it is typed. Child makes about 150 characters, plays with the carriage return and paper advance, examines the ribbon, attempts to examine the side and back of the typewriter, and shows signs of being aware of the teacher's responses.]

I believe that you will agree that he is motivated--his curiosity is evident. And in thinking about curiosity, let us remember that there are many experimental studies showing that organisms, which are sated with respect to so-called primary drives and are not subject to stress, spend long periods in free play and exploration. (See, for example, the studies by Butler [6], Harlow [7], Dashiell [8], Montgomery [10], Myers and Miller [16], Nissen [18], Zimbardo and Miller [20].) For a summary of the literature on curiosity and an inciteful reinterpretation of the concept of motivation see White's essay, "Motivation reconsidered: the concept of competence" [19].

Stage I of the training consists of three parts: typing, printing, and reading. I do not have films showing children going through every step of Stage I. There are practical reasons for this--the making of motion pictures is expensive and time-consuming, as well as disruptive of the training (unless one has an appropriately designed motion picture studio). The films shown today were made under adverse conditions. The children were photographed under hot lights, the cameramen were strangers to the children, and the room was filled with fascinating photographic equipment. Also, shooting these films without a suitable studio imposed conditions on the children which are antithetical to the concept of a responsive environment. The striking thing is that, for the most part, the children retained their interest in symbols under these novel circumstances.

Now let us watch three children who are well along in Stage I of the training. Each of these children types, prints and is beginning to read. Two of the children have been under training for approximately fourteen weeks, and one for thirty-three weeks. In the following excerpt you will see two boys and a girl. The boys are about equal in measured intelligence--they are one standard deviation above average. Each is rated as well-adjusted and, again, the social class position is in the III to IV range. The younger boy is three-years seven-months old, the older boy is five-years six-months. The little girl, age three-years four-months, an only child, is my daughter. She was a premature, cleft-palate baby and at two years of age underwent corrective surgery. According to Hollingshead's index we are a Class II family.

Two independent assessments of her intelligence, made before the beginning of her training, placed her in the category "gifted." It might be appropriate here to mention that of the 35 children with whom I have worked two are "gifted"; both are girls and they exceeded all of the other children in rate of learning and amount of time spent per session of training. This responsive environment for children is so arranged that a child has the option of either not going into it or of leaving it at will.[4] An upper limit was set of one hour for a session and one session a day. The average time spent by all children per session is approximately thirty minutes; the gifted children, as well as some of the others, frequently were annoyed by having to stop at the end of the hour.

Film Excerpt 2

[from EARLY READING AND WRITING: PART 1 [13]--sixteen minutes.

Scenes:

1. girl (3 yrs, 4 mos) typing second-grade story
2. first boy (3 yrs, 7 mos) beginning to type a first-grade story
3. second boy (5 yrs, 6 mos) typing first-grade story
4. first boy printing upper-case letters at blackboard
5. second boy printing upper-case letters at blackboard
6. second boy printing word
7. girl printing lower-case letters on a line
8. second boy reading word list (and sounding out some words phonetically)
9. second boy reading first-grade story
10. girl reading second-grade story]

All of these children learned very rapidly within the context of a responsive environment.[5] It should be pointed out that not only

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[4]It should be clear that a child not only has the option of entering or leaving the environment, but that also he sets his own pace within it. In brief, the child controls the situation. He is in no sense pushed or forced.

[5]The fact that children learn so rapidly makes the question as to what they should be exposed to a critical one. I considered devising an artificial language to be used for experimental purposes. However, I soon decided that if I were correct about how rapidly children could learn (and also that perhaps early learning is irreversible), then it would be unfortunate for them to internalize "experimentalese."

was the environment responsive in the sense previously discussed, but that the children's activities within it were made as autotelic as could be managed at the time. Anderson and I stipulate that an activity is autotelic if it is engaged in for its own sake and not because of extrinsic rewards or punishments. Every effort was made to protect the experimental environment from extraneous influences. For example, each child is trained individually--there is no rivalry or competition among the children. Parents are not informed about how a child does on a given day--so a child can fail to make progress without alarming his parents, or do very well without receiving bonuses. In the case of my daughter, extensive use was made of other people as instructors. It is true that a child's participation in the experiment was given positive support by the parents and the teachers--but this support was general rather than specific to the learning of any particular thing. This film excerpt also reveals that instructors sometimes err by showing signs of approval or disapproval; this is a mistake from the point of view of the theoretical rationale of the training methods. Later, mention will be made of modifications of the techniques which will make it easier to control the inadvertent occurrence of acts of approval or disapproval. In addition, these modified techniques will make it possible to study the effects of systematically varying the amount of approval or disapproval expressed by the instructor.

The film excerpts which you have seen up to now give a relatively static impression of the behavior of these children in a responsive environment. In order to give an indication of the dynamics of one child's development within this kind of an environment, the next two excerpts will show my daughter at two-years eleven-months, three-years four-months and three-years eleven-months. She began to explore the typewriter at two-years seven-months, thus you will see her after 19, 33 and 68 weeks of learning. By the end of 68 weeks she was reading at the fourth-grade level, typing autonomously, printing, and taking third-grade material in dictation. In sum, she had completed all but the fourth stage of the training as it is presented in the outline.

Film Excerpt 3

[from EARLY READING AND WRITING: PART 3 [15], fifteen minutes.

Scenes: girl

1. 2 yrs, 11 mos, printing all upper-case letters
2. 2 yrs, 11 mos, printing sentence
3. 3 yrs, 4 mos, printing lower-case letters
4. 2 yrs, 11 mos, typing simple sentences
5. 3 yrs, 4 mos, typing second-grade story
6. 2 yrs, 11 mos, going over word list
7. 2 yrs, 11 mos, reading first-grade story
8. 3 yrs, 4 mos, reading second-grade story]

Film Excerpt 4

[from DICTATION [12]--fifteen minutes.

Scenes: girl, 3 yrs, 11 mos.

1. typing autonomously
2. reading third-grade story which is being recorded on a recording-reproducing unit
3. taking her own dictation[6]]

In Stage I of the training children learn to "translate" written symbols into speech. In Stages II, III and IV they learn to go from speech to written symbols. The last two excerpts show that a three-year-old child can "induce" a set of transformation rules which are sufficiently powerful to allow the child to "translate" freely from written symbols to spoken ones, and from spoken symbols to written ones. The child has discovered for herself the answers to a series of complex interconnected prospective problems.

DICTATION was the last of the film excerpts which will be shown today. Plans are being made for a film series on the children with whom I am currently working. The films which you have seen are of the most primitive version of my teaching techniques.

As an addendum to the discussion of the four stages of the training, let me make a few statements about the relation between them and personality development. I modeled the stages of the training to

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[6]For her to take her own dictation she must have mastered a system with 60 distinct controls, 54 on the typewriter and 6 on the projector and recording-reproducing unit. Of course, most keys on the typewriter make two different characters, depending upon the position of the shift key. Taking this into account, there would be almost twice as many controls to master.

match George Herbert Mead's account of the development of a "social self." For those of you who are familiar with Mead's work (e.g., [19]), you may have noticed that this responsive environment is planned so that a subject is implicated in a "conversation of gestures" and that eventually "significant symbols" emerge from this conversation of gestures as it takes place within the context of a miniturized social process. Stages II, III and IV of the training are designed to facilitate the development of the "I-me," the "self-significant other," and the "other-generalized other" differentiations. In my opinion, this responsive environment, taken as a whole, constitutes an operational specification of Mead's central concepts. If this is so, and if Mead's intuitions about personality development are sound, then it is to be expected, other things being equal, that engaging in autotelic activities within a responsive environment will aid in the development of a more adequate social self. While we are considering the Meadian position, it is interesting to speculate as to whether it is necessary to have a human instructor in a responsive environment. In other words, if, through automation, a special purpose computer were to replace the human instructor, then would children learn as well? Would children enjoy the experience as much as they do with the present scheme of training? It would open up intriguing possibilities to have a fully automated responsive environment. With a computer as an instructor there would be no inadvertent expressions of approval or disapproval, or at least, if they occurred, then they would have been written into the computer's program. Currently, engineers at the Thomas A. Edison Research Laboratory and I are at work designing automated responsive environments; this is one of the new directions the research is taking.

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EARLY READING AND WRITING

A FILM REPORT
BY
OMAR K. MOORE
AND
ALAN ROSS ANDERSON

PRODUCER: WM. D. STONEBACK

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Many recent controversies concerning educational policy have revolved around estimates of the capacities of children. This report provides an invitation to reconsider these issues, by showing results of some new teaching methods involving the use of the electric typewriter. Part 1 shows some pre-school children, age three to five, who have begun learning to read and write, with pleasure and enjoyment. Part 2 sketches the teaching method, which provides an opportunity for the child to make a series of inter-related discoveries under conditions which allow him a large measure of freedom. A child two years seven months old is shown in his first experience with an electric typewriter. Part 3 gives an indication of the rate at which learning can take place, by showing one child at two stages in the training. She began at two years seven months, and she is shown at two years eleven months reading a first-grade story, printing the alphabet, and typing on an electric typewriter with correct fingering. The film also shows her improvement over the succeeding 14 weeks.

In addition to its intrinsic interest, this film should have some historical value... it is the first film documentation of a child reading, printing and typing - before the age of three - thus providing an unmistakable counterexample to the thesis that such learning is impossible before three!

FOR USE IN DISCUSSION GROUPS, AND IN CLASSES IN EDUCATIONAL THEORY AND PRACTICE, LEARNING THEORY, CONCEPT FORMATION AND PROBLEM SOLVING, CHILD PSYCHOLOGY, SOCIAL PSYCHOLOGY, SMALL-GROUP THEORY, LANGUAGE AND CULTURE, CULTURE AND PERSONALITY, ETC.

FOR STUDY GROUPS, THESE FILMS MAY SERVE TO ELICIT DISCUSSION OF SUCH TOPICS AS THESE:

Are we underestimating the capacities and interests of our pre-school children?

Are we making enough use of our rich technology in educating our children?

Can research in the behavioral sciences be brought to bear on fundamental problems in education?

ABOUT THE FILM....

Early Reading and Writing was produced for Basic Education Inc. by Wm. D. Stoneback. The series of 16mm sound-color films runs for 49 minutes. The three parts (15, 18, and 16 minutes respectively), may be shown separately, but are rented and sold only as a unit, and (since colors are essential throughout) only in color. The film reports one phase of a research program, currently in progress, which combines theoretical investigations of human higher-order problem solving and social interaction with experimental applications--the application with pre-school children shown in the film providing an example.

- OMAR K. MOORE, Ph. D. (Sociology), formerly of Washington University (St. Louis), Northwestern University, and the Naval Research Laboratory, is now Associate Professor of Sociology and Director of the Interaction Laboratory at Yale University.
- ALAN ROSS ANDERSON, Ph. D. (Philosophy), formerly of Dartmouth College, is an Assistant Professor of Philosophy at Yale University, and consulting editor to the Journal of Symbolic Logic.
- WM. D. STONEBACK, Producer of Alumni Films in the Yale University Audio Visual Center, is associated with Weston Woods Studios, where he participated in the development of the "Picture Book Parade" series of children's films and film strips.

BASIC EDUCATION, INC., Little Harbor. Guilford, Conn. Tel. Glendale 3-9503

EARLY READING AND WRITING PRODUCER: WM. D. STONEBACK

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